PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G02F 1/1333, C03B 33/02 | A1

(11) International Publication Number: **WO 99/19765**

(43) International Publication Date: 22 April 1999 (22.04.99)

(21) International Application Number: PCT/GB98/02586

(22) International Filing Date: 27 August 1998 (27.08.98)

(30) Priority Data:
9721804.4 15 October 1997 (15.10.97) GB
9814577.4 7 July 1998 (07.07.98) GB

(71) Applicant *(for all designated States except US)*: GEC MARCONI AVIONICS (HOLDINGS) LIMITED [GB/GB]; The Grove, Warren Lane, Stanmore, Middlesex HA7 4LY (GB).

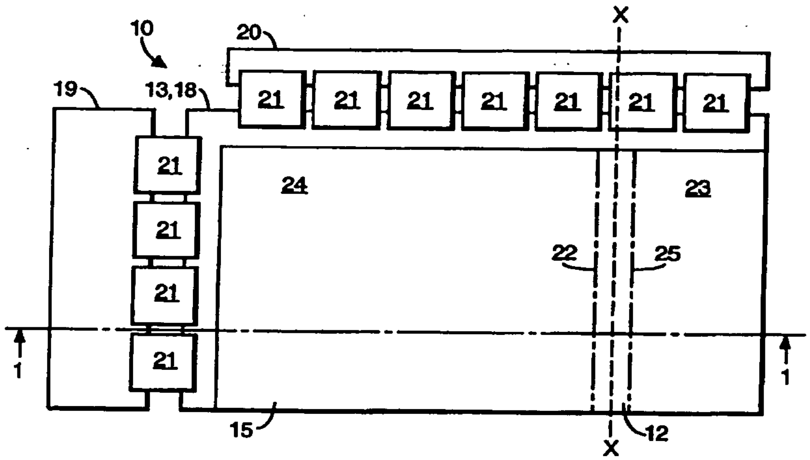
(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: WATSON, David, Stewart, Nimmo [GB/GB]; 7 Colinton Grove, Edinburgh EH14 1DB (GB).

(74) Agent: HOSTE, Colin, Francis; GEC Patent Dept., Waterhouse Lane, Chelmsford, Essex CM1 2QX (GB).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: IMPROVEMENTS IN OR RELATING TO LIQUID CRYSTAL DISPLAYS



(57) Abstract

A custom made liquid crystal display is formed from a pre-manufactured liquid crystal display (10) by removing an excess region (23). The driver card (20) is cut along the line X–X and the excess TABs are disconnected from the conductive layer (18). Optionally, a narrow strip is removed from each of the polarising substrates (15, 16) between the lines (22, 25) to expose their associated glass plates (12, 13). A groove (32 – see Figure 10) is then cut into the exposed surface of each of the glass plates (12, 13) along the line X–X. Each glass plate (12, 13) is then fractured along the base of its groove (32) so that the excess region (23) is detached from the operative region (24). The cut edges of the glass plates (12, 13) are then sealed by applying a bead of ultra-violet curing adhesive. The processes of removing an excess region (23) by cutting the glass plates (12, 13) with a laser or by freezing the liquid crystal between the glass plates (12, 13) and machining through the glass plates (12, 13) are also described.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Fig.1.

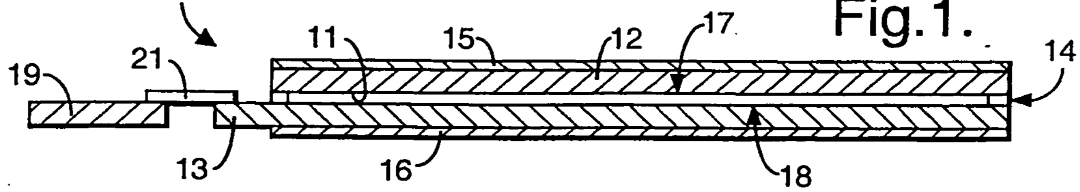


Fig.2.

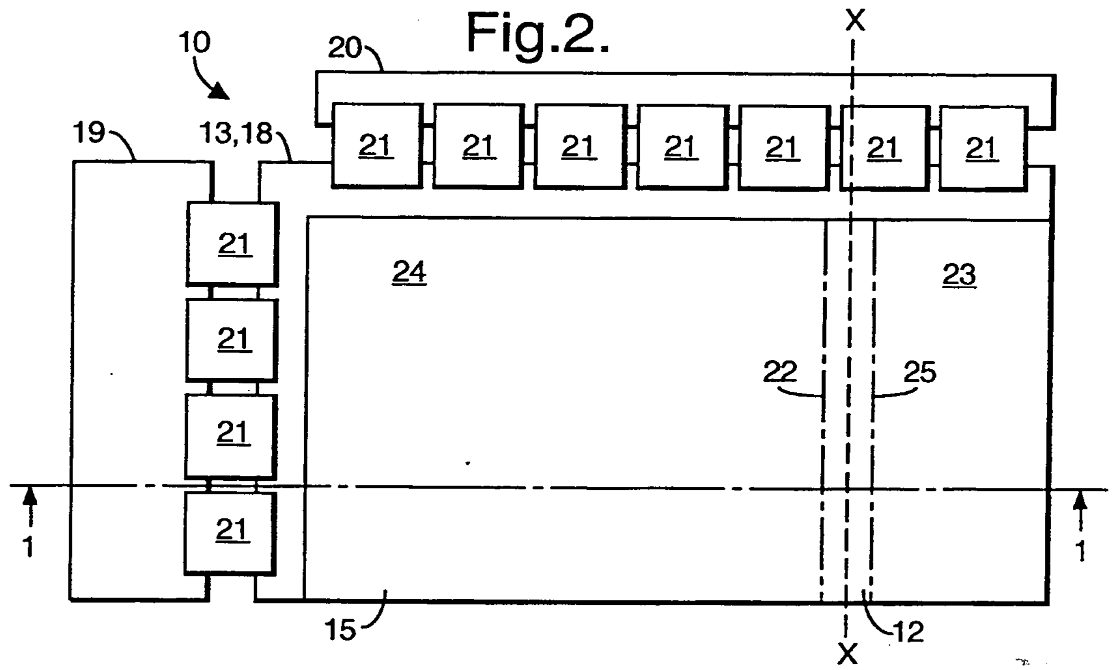


Fig.3.

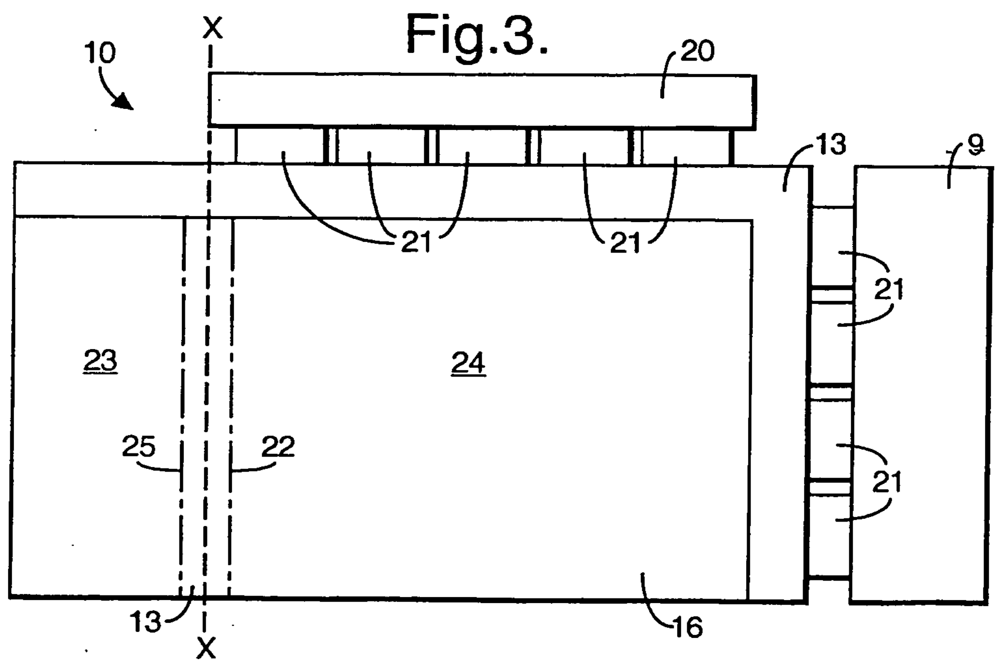


Fig.4.

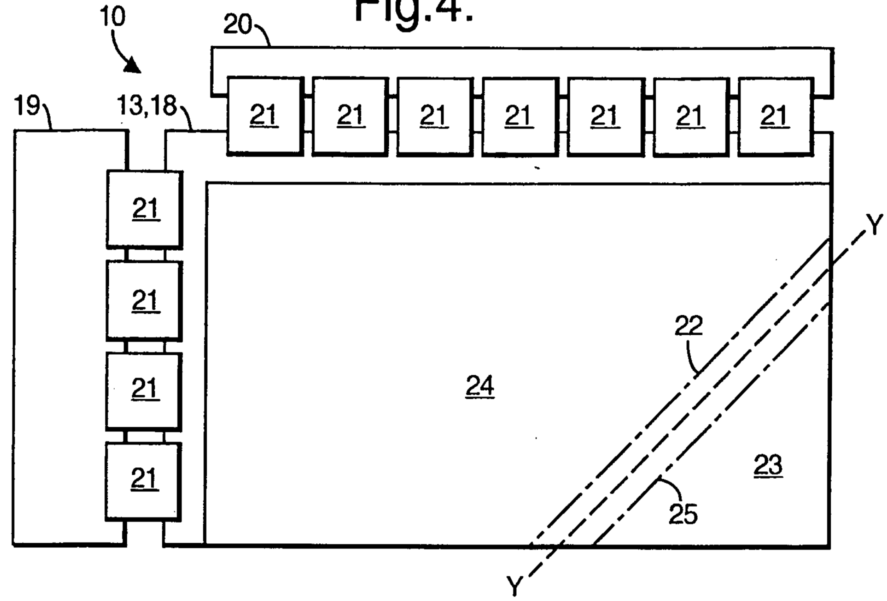

10
20
19
13,18
21
21
21
21
21
21
21
21
21
21
21
Y
22
24
23
25
Y

Fig.5.

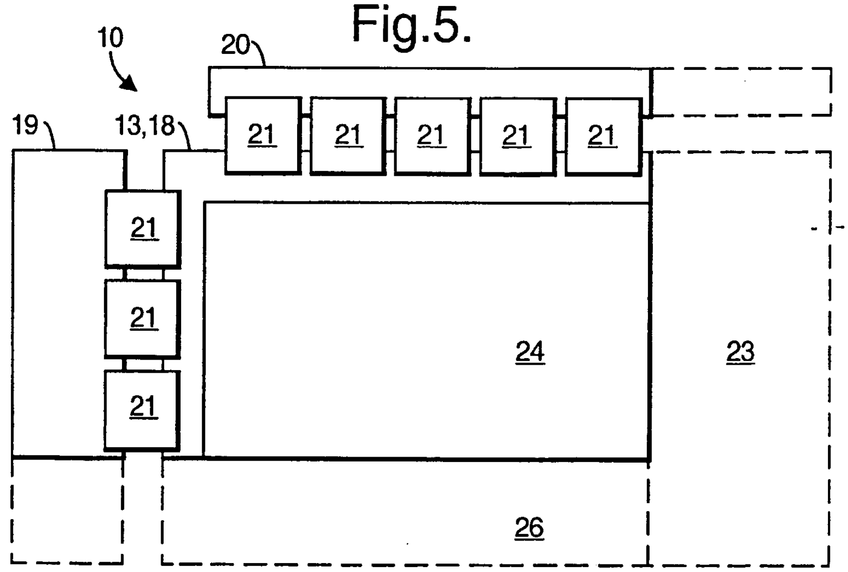

10
20
19
13,18
21
21
21
21
21
21
21
21
24
23
26

Fig.6.

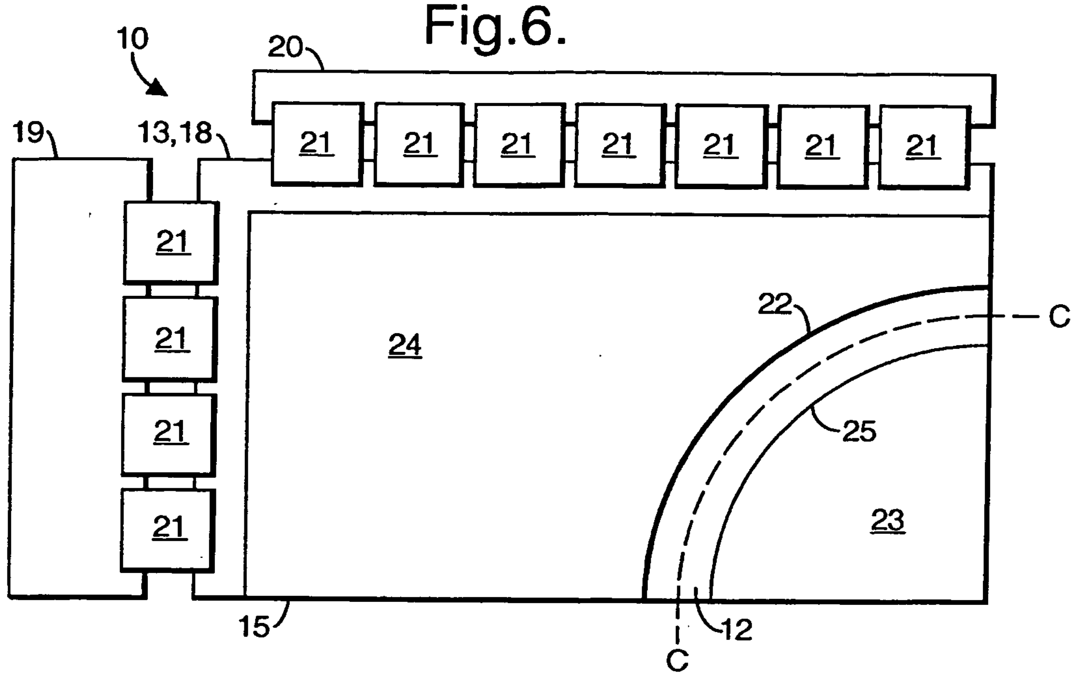

10
20
19
13,18
21
21
21
21
21
21
21
21
21
21
21
22
C
24
25
23
15
12
C

Fig.7.

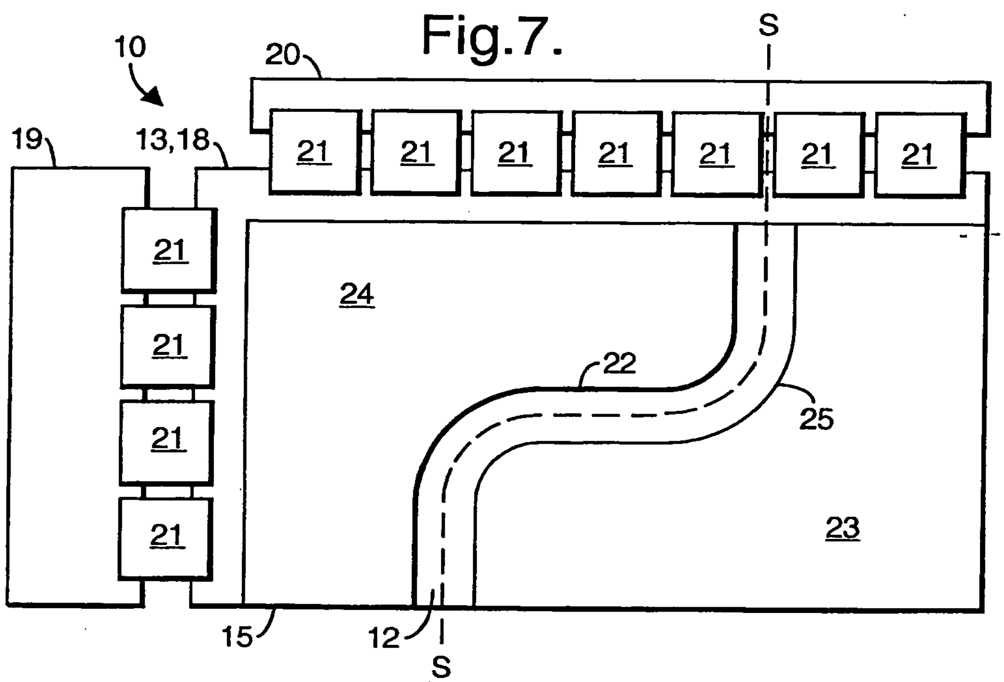

S
10
20
19
13,18
21
21
21
21
21
21
21
21
21
21
21
24
22
25
23
15
12
S

Fig.8.

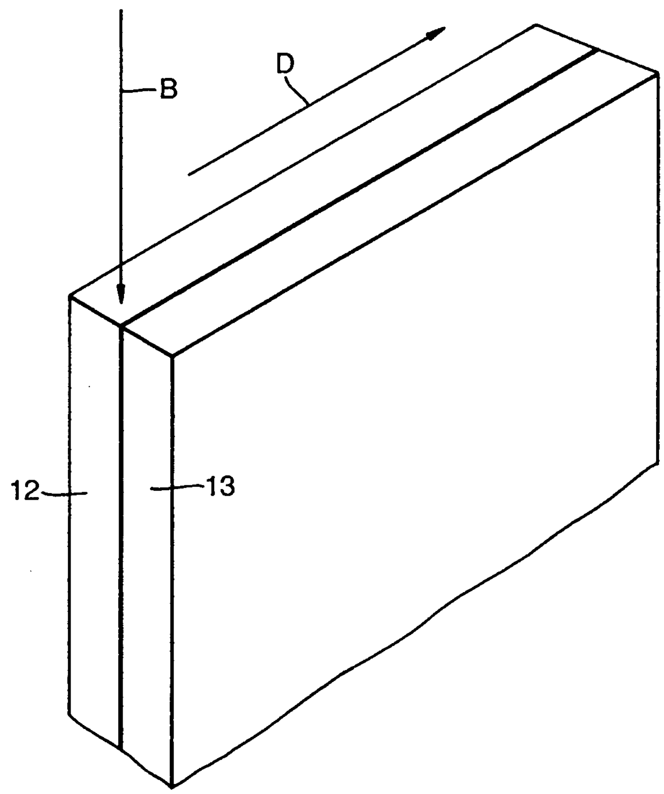


Fig.9.

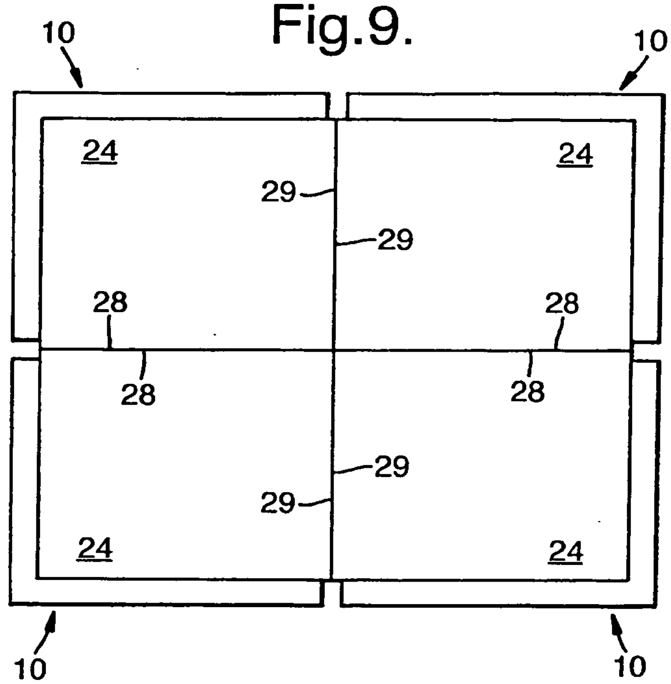
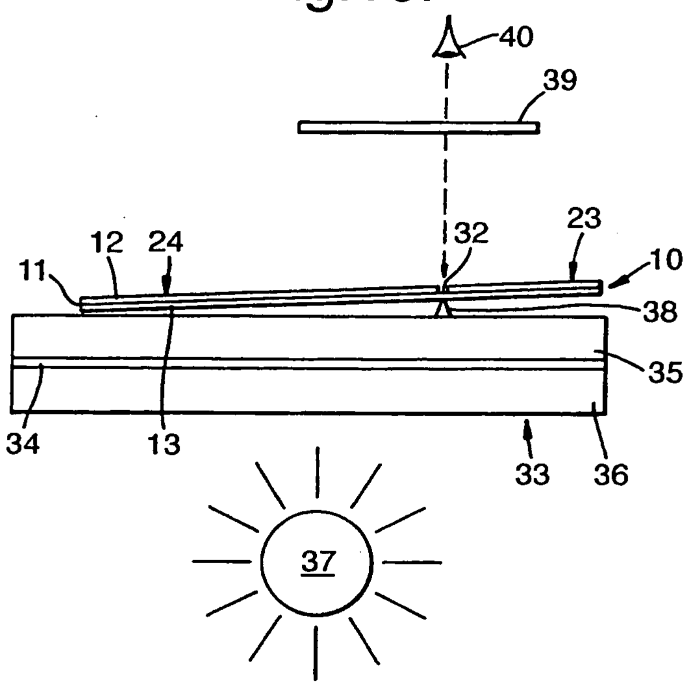

10
10
24
24
29
29
28
28
28
28
29
29
24
24
10
10

Fig.10.


40
39
12
24
32
23
11
10
38
35
34
13
33
36
37

INTERNATIONAL SEARCH REPORT

Inte   onal Application No
PCT/GB 98/02586

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02F1/1333 C03B33/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	US 5 808 719 A (SHARP) 15 September 1998 see column 5, line 37 - column 13, line 12; figures 13,20	1-7,9, 17, 19-21, 24-26
X	-& JP 08 076074 A (SHARP) 22 March 1996 see figures 13,20 ---	1-7,9, 17, 19-21, 24-26
X	PATENT ABSTRACTS OF JAPAN vol. 96, no. 10 & JP 08 146444 A (NIPPONDENSO), 7 June 1996 see figures A-D --- -/--	1,14

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 November 1998	03/12/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Diot, P

2

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 98/02586

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 245 (P-881) & JP 01 048024 A (SEIKO), 22 February 1989 see abstract ---	5
X	JP 08 122769 A (SHARP) 17 May 1996 see figure 3B	1,20
E	-& US 5 812 226 A (SHARP) 22 September 1998 see figures 1,20 ---	1,20
A	WO 93 11452 A (MAGNASCREEN) 10 June 1993 see page 5, line 09 - line 30 ---	1,20
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 194 (P-1722), 5 April 1994 & JP 06 003633 A (FUJITSU LTD), 14 January 1994 see abstract ---	29
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 093 (C-220), 27 April 1984 & JP 59 008632 A (MITSUBOSHI DIAMOND KOGYO KK), 17 January 1984 see abstract -----	29-32

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter.   nal Application No
PCT/GB 98/02586

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5808719 A	15-09-1998	JP 8076074 A	22-03-1996
JP 8122769 A	17-05-1900	CN 1120178 A	10-04-1996
		US 5812226 A	22-09-1998
WO 9311452 A	10-06-1993	US 5353133 A	04-10-1994

IMPROVEMENTS IN OR RELATING TO LIQUID CRYSTAL DISPLAYS

This invention relates to a liquid crystal display, to a method of manufacturing a liquid crystal display, and also to apparatus to aid manufacture of a liquid crystal display.

Generally, displays for reproduction of information have historically been of a cathode ray tube type construction. In an environment where space is limited traditional displays were typically manufactured to be square, or square with rounded corners, in order to make the best use of the limited space available.

Liquid crystal displays are currently considered suitable substitutes for applications previously requiring cathode ray tube technology. The replacement of cathode ray tubes can be either for new applications or for the purpose of upgrading existing technology through retrofit design. When manufactured in large quantities, liquid crystal displays are of modest cost compared with an equivalent cathode ray tube.

However, when liquid crystal displays need to be custom made in relatively low numbers to suit specific requirements, the cost per unit is very high due to expensive tooling and manufacturing charges. Furthermore, manufacturing yield rates are low, high pixel defect levels have to be tolerated and there are substantial delivery delays.

It is an objective of the present invention to facilitate the production of custom made liquid crystal displays.

According to a first aspect of the present invention, a method of manufacturing a liquid crystal display having a liquid crystal sealed between first and second substantially parallely spaced transparent plates which form an operative area of the display, comprises removing an excess region of a pre-manufactured liquid crystal display by cutting the first and second plates to isolate the excess region of the first and second plates and to expose cut edges along the operative areas of the first and second plates.

The terms "cutting" or "cut" as used throughout this document means the action of separating an excess region from an operative region in any way. For example, this may be achieved by grooving and then fracturing a plate, or cutting through a plate with a laser or machine tool.

The inventor has determined that, contrary to the present understanding of the nature of liquid crystal displays, the highly complex electronic and physical structure of such displays can be re-manufactured to provide alternative shaped displays at a much reduced cost per unit, when compared with the cost of a custom made display, and without substantial damage to the display. Furthermore, standard sized displays are readily available devices which may be found in personal computers and other products which use standard sized liquid crystal displays and are manufactured in very high volumes, and hence at low cost. A liquid crystal display comprises a liquid crystal sealed between first and second parallely spaced transparent plates which form an operative area of the display. In such a display there is a miniscule spacing between the plates. The inventor has discovered that this spacing, when the plates are re-manufactured, exerts a capillary action on the liquid crystal which retains the liquid crystal between the plates without appreciable loss or disruption of

the liquid crystal.

By using a method in accordance with the invention, it is possible to start with an inexpensive standard display and re-fashion it to particular requirements, instead of designing and manufacturing a small number of expensive custom displays or ordering such custom displays from a specialist manufacturer with an added high premium.

The transparent plates are usually formed from glass or another suitable transparent material. The method may include cutting the first and second plates at an oblique angle.

The method may also include removing the excess region of the pre-manufactured liquid crystal display by forming a first groove in the first plate of sufficient depth to isolate the excess region of the first plate, forming a second groove in the second plate of sufficient depth to isolate the excess region of the second plate, the second groove being substantially aligned with the first groove, and fracturing the first plate and second plate along their respective grooves.

The method may include forming the first and second grooves simultaneously and may also include fracturing the first and second plates simultaneously along the first and second grooves.

The method may include fracturing the first plate along the first groove prior to forming the second groove in the second plate and fracturing the second plate along the second groove.

The method, may further include fracturing each grooved plate by placing the other plate on a ridge substantially corresponding with the groove and applying pressure to the excess region.

Preferably, the liquid crystal display is placed on an apparatus comprising a fracturing platform having a first light polarising layer to polarise radiation emitted from a radiation source and a second light polarising layer located between a viewer's eye position and the liquid crystal display, and the method may include viewing the propagation of each fracture along its groove as an area against a contrasting background through the second light polarising layer.

Alternatively, the method may include removing the excess region of the pre-manufactured liquid crystal display by cutting the first and second plates using a laser beam thereby isolating the excess region of the first and second plates and exposing the cut edges along the operative areas of the first and second plates. The laser beam may cut entirely through both plates, and this may done from one side of the display. Use of a laser to cut the plates gives good control of the cutting process and is particularly suitable where more complex or rounded configurations are required. It is also envisaged that a laser beam can be used to form grooves in each plate and then pressure applied to the excess area to fracture each plate along the groove. In this manner contamination of the liquid crystal is avoided since the plates may be cleaned after grooves has been formed.

In a further alternative, the method may include removing the excess region of the pre-manufactured liquid crystal display by freezing the liquid crystal between the first and second

plates and machining through the first and second plates thereby isolating the excess region of the first and second plates and exposing the cut edges along the operative areas of the first and second plates. It will be understood that the term freezing includes any reduction in the viscosity of the liquid crystal thereby inhibiting its egress from between the first and second plates.

Although freezing is particularly applicable to this further alternative, it may also be used in other methods in accordance with the invention, for example, when a laser beam is used or the plates are fractured following grooving. Accordingly, the method may include freezing the liquid crystal between the first and second plates prior to cutting the first and second plates.

In the case where conductive layers are adhered to the first and second plates and are electrically connected to driver connections, the method may also include cutting and removing any driver connection associated with the excess region prior to cutting the first and second plates. In the case where a light polariser is adhered to at least one of the plates, the method may include cutting and removing a narrow strip of the light polariser in a region either side of where the cut edge associated with each plate is to be formed.

The method may also include removing air voids within the liquid crystal by applying pressure to at least one of the plates.

Preferably, the method may include sealing the exposed fractured edges to retain the liquid

crystal between the first and second plates. The method may include sealing the exposed cut edges using a laser beam arranged to melt the first and second plates together along the exposed cut edges. This is particularly convenient where a laser beam is used to remove the excess region.

Alternatively, the method may include removing an excess region from at least two pre-manufactured liquid crystal displays to leave exposed cut edges, aligning and positioning the exposed cut edges of one of the liquid crystal displays with the corresponding exposed cut edges of an adjacent liquid crystal display, and laminating the liquid crystal displays to form a single display with increased operative area.

According to a second aspect of the invention, a liquid crystal display comprises a pre-manufactured liquid crystal display having a liquid crystal sealed between first and second parallely spaced transparent plates and in which an excess region of the pre-manufactured liquid crystal display has been removed by cutting both of its transparent plates along a common line. In this manner a modified liquid crystal display is provided as a selected portion of a pre-manufactured liquid crystal display.

The first and second plates may be cut at an oblique angle. The cut edges of the transparent plates may be resealed to retain the liquid crystal. A laser beam may be used to melt the first and second plates together.

A composite liquid crystal display preferably comprises at least two of these modified liquid crystal displays supported with their respective cut edges aligned and abutting. The cut

edges are preferably supported in alignment by a transparent lamina adhered over their first transparent plates. The cut edges may additionally be supported in alignment by a second lamina adhered over their second transparent plates.

According to a third aspect of the present invention apparatus, to aid removal of an excess region of a pre-manufactured liquid crystal display having liquid crystal sealed between first and second parallel spaced transparent plates which form an operative area of the display and in which a groove has been formed in one of the plates between the excess region and an operative region of the liquid crystal display, comprises a fracturing platform having a light polarising layer located between transparent first and second supporting surfaces, a radiation source located to emit radiation through the fracturing platform, a raised region arranged on an opposite surface of the fracturing platform to which the light source is located, the raised region being arranged to contact a plate of the liquid crystal display in a region substantially corresponding to the groove in the other plate, and a light polarising layer disposed between a viewer's eye position and a liquid crystal display located on the fracturing platform. In this manner a viewer observes the liquid crystal display as a dark area and when the viewer applies pressure to the excess region any fracture in the grooved plate appears as a light area.

The operative area of the liquid crystal display may be clamped to the fracturing platform whilst leaving the excess region freedom of movement. The raised region may be a ridge.

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic cross-section through a conventional prior art liquid crystal display taken along the line 1-1 in Figure 2;

Figure 2 is a plan view of the pre-manufactured liquid crystal display illustrated in Figure 1, but showing the removal of an excess region along its right-hand edge;

Figure 3 is an underplan view of the liquid crystal display illustrated in Figure 2;

Figure 4 is a plan view similar to Figure 2, but showing the removal of an excess region along its right-hand lower corner;

Figure 5 is a plan view of a pre-manufactured liquid crystal display that has been processed by removing a first excess region along its right-hand edge and a second excess region along its bottom edge to provide a decreased display area;

Figures 6 and 7 are plan views of pre-manufactured liquid crystal displays which have been processed to remove curved excess regions.

Figure 8 schematically illustrates sealing of cut edges formed in a pre-manufactured liquid crystal display.

Figure 9 illustrates the processing of four pre-manufactured liquid crystal displays, each similar to that shown in Figure 5, to provide an increased display area, and

Figure 10 is a diagrammatic side elevation of apparatus for aiding removal of an excess area of a pre-manufactured liquid crystal display.

In Figure 1, a typical liquid crystal display 10 comprises liquid crystal 11 trapped between first and second parallely spaced transparent glass plates 12, 13 by an ultra-violet cured adhesive seal 14. Patterned light polarising substrates 15, 16 are respectively adhered to the outer surfaces of the glass plates 12, 13. Very thin conductive layers 17, 18 are respectively coated over the inner surfaces of the glass plates 12, 13 and are used to generate an electric field between corresponding portions of the conductive layers 17, 18 to cause the liquid crystal 11 in the field to rotate and block light from passing. No light can pass the rotated electric crystal within the electric field and a viewer will observe a dark area corresponding to the shape of the electric field. By controlling a plurality of such corresponding portions of the conductive layers 17 and 18, the liquid crystal display 10 can be operated to convey information to the viewer.

In a first embodiment, as will be seen from Figures 1 and 2, the glass plate 13 and its associated conductive layer 18 are larger than the glass plate 12 so that they extend to the left towards a vertical driver card 19, and upwards towards a horizontal driver card 20. A series of ribbon connectors or TABs 21 electrically interconnect the driver cards 19 and 20 with the various portions of the conductive layers 17 and 18 in well-known manner so that the driver cards 19, 20 will determine which portions of the conductive layers 17 and 18 are to be energised.

Figure 3 shows the reverse side of the liquid crystal display 10, the reverse side of the

vertical and horizontal TAB's 21, driver cards 19 and 20, and the light polarising substrate 16.

In Figures 2 and 3 the required width of the final liquid crystal display 10 is indicated by a chained line 22 and is achieved by removing an excess region 23 of the liquid crystal display 10 in the following manner. With reference to Figure 2, one of the vertical driver cards 20 is cut, using any suitable cutting apparatus, along a broken line X-X which is located just outside an operative region 24 of the liquid crystal display 10 that is to be retained. The vertical driver card 20 may be held in a support fixture, not shown, and a fine tooth saw may be used to cut through the vertical driver card 20 along the line X-X. This cut must be beyond any TAB 21 carrying connections to the operative region 24 that are to be retained. Any rough edges can be filed to prevent any track cut from shorting.

The portion of the vertical driver card 20 for the excess region 23 is then removed by disconnecting the corresponding TABs 21 using a suitable solvent or heating process. In this manner the removed portion of the vertical driver card 20 and associated TABs 21 are not damaged and can be retained for potential repair use.

Optionally, a narrow strip of the light polarising substrate 15, defined by the chained line 22 and a parallely-spaced chained line 25 on the opposite side of the line X-X, is then removed using suitable cutting apparatus which will not damage the exposed portion of the underlying glass plate 12. For example, a scalpel can be used to cut along the lines 22, 25 so that the narrow strip of the light polarising substrate 15 can be peeled off to expose the glass plate 12 which is then cleaned to remove all traces of the adhesive that was used to bond the strip

of the light polarising substrate 15 to the glass plate 12.

A groove is then formed in the glass plate 12 along the line X-X of sufficient depth to promote the generation of a fracture along the length of the groove when pressure is applied to the excess region 23. This groove can be formed using a scribe, a machine tool set to machine a controlled depth, or a diamond wheel cutter. It may also be possible to use a laser beam operated to form a groove of controlled depth. An apparatus used to aid removal of the excess region 23 is described below with reference to Figure 7.

The liquid crystal display 10 is then reversed to expose its opposite surface as shown in Figure 3. Again, optionally a narrow strip of the polarising substrate 16 is removed from either side of the line X-X to expose a region of the glass plate 13. The process of removing the narrow strip of the substrate 16 is the same as that already described for the removal of the narrow strip of the substrate 15. The exposed portion of the glass plate 13 is then cleaned to remove all traces of the adhesive that was used to bond the strip of the light polarising substrate 16 to the glass plate 13. A groove is then formed in the glass plate 13 along the line X-X of sufficient depth to promote the generation of a fracture along the length of the groove when pressure is applied to the excess region 23. This can again be achieved by using the apparatus that is described below with reference to Figure 7.

It will be understood that either a groove can be formed in glass plate 12 and the glass plate then fractured along that groove prior to forming a corresponding groove in the other glass plate 13 or corresponding grooves can be formed in both glass plates 12, 13 prior to forming fractures in each plate 12, 13.

By fracturing the glass plates 12 and 13 along the line X-X, the excess region 23 of the liquid crystal display 10 can be removed to expose cut edges of the glass plates 12 and 13. The minuscule spacing between the glass plates 12 and 13 generates a capillary action which acts on the liquid crystal 11 and serves to retain the liquid crystal 11 between the glass plates 12 and 13 so that no appreciable loss or disruption of the liquid crystal 11 occurs.

The process of removing the excess region 22 can create minute voids in the liquid crystal 11, particularly if the cut edges of the transparent plates 12 and 13 do not coincide. Provided the fractures form a clean break, these voids rapidly disappear. Gentle pressure applied to the glass plates 12, 13 can also be used to eliminate some voids and manoeuvre persistent voids to the cut edges and hence out of the liquid crystal 11. Positioning the line X-X along which fractures are formed further away from the operative region 24 reduces the risk of voids or bubbles being formed.

Although the glass plates 12 and 13 could be cut right through along the line X-X, as described below with reference to Figures 6 to 8, there is an increased chance of contaminating the liquid crystal 11 in the operative region with particles of glass and cutting fluid. By only partly cutting through the glass plates 12 and 13, such contaminants can be positively excluded from contact with the liquid crystal, and the glass plates 12 and 13 can be cleaned before being fractured along the line X-X.

If desired, the grooves in the glass plates 12 and 13 can be formed simultaneously by feeding the liquid crystal display between a pair of diamond wheel cutters, thereby also ensuring that the two grooves are parallely aligned. It will be understood that the grooves formed in glass

plates 12, 13 and the cutting of the polarising substrates 15, 16 can be performed in a single action.

Irrespective of whether the grooves in the glass plates 12 and 13 are formed separately or at the same time, in this particular embodiment, the cut edges of the glass plates 12 and 13 are sealed by applying a bead of ultra-violet curing liquid crystal display sealant adhesive, and then curing with an ultra-violet light source. This process provides a liquid crystal display 10 having a reduced operative region 24 without the need to commission the production of a custom display by a manufacturer.

Figure 4 illustrates a modification of the process described with reference to Figure 2 to permit the liquid crystal display 10 to be chamfered, that is to have a corner removed. The same reference numerals have been used as in Figures 2 and 4 to denote equivalent features and only the points of difference are now described. The excess region 23 is removed from the operative region 24 along a broken line Y-Y which is inclined to both of the card drivers 19 and 20. The removal process is exactly the same as described with reference to Figure 2 except that there is no need to cut the vertical card driver 20 or to remove any TAB 21.

Figure 5 show how the liquid crystal display 10, produced as described with reference to Figures 1 to 3, can have its operative region 24 reduced still further by removing a horizontal excess region 26 together with the lower portion if the horizontal card driver 19 and associated TAB 21.

Figures 6 and 7 illustrate a second embodiment of the process for removing an excess region

from a pre-manufactured liquid crystal display. The same reference numerals have been used as those in Figures 2 to 5 to denote equivalent features.

The required shape of the final liquid crystal display 10 is indicated by a solid line 22 and is achieved by removing an excess region 23 of the liquid crystal display 10 in the following manner.

With reference to Figure 6, narrow strips of light polarising substrate 15, 16, defined by the solid line 22 and a parallely-spaced line 25 on the opposite side of broken line C-C, are optionally removed from both sides of the liquid crystal display 10 and the exposed areas cleaned, as previously described. A laser, not shown, is then used to cut through glass plate 12 and glass plate 13 along line C-C. In this manner both glass plates 12, 13 are cut at the same time and the excess region 23 of the liquid crystal display 10 can be removed to expose cut edges of the glass plates 12 and 13.

With reference to Figure 7, a portion of the vertical driver card 20 for the excess region 23 is cut and removed by disconnecting the corresponding TAB's 21, as previously described. Narrow strips of light polarising substrate 15, 16, define by the solid line 22 and a parallely-spaced line 25 on the opposite side of broken line S-S, are optionally removed from both sides of the liquid crystal display 10 and the exposed areas cleaned, as previously described. A laser, not shown, is then used to cut through glass plate 12 and glass plate 13 along line S-S simultaneously, as previously described, to expose cut edges of the glass plates 12 and 13.

It will be understood that although Figures 6 and 7 illustrate curved lines C-C and S-S the process of cutting with a laser can equally be applied to the straight line cuts shown in Figures 2 to 5 or other cut shapes not illustrated. Furthermore, the laser may be used to cut through the driver card and polarising substrate.

The gap between the plates 12 and 13 is then sealed either by applying a bead of ultra-violet curing sealant adhesive and curing under ultra-violet light conditions, or applying a glass frit or using the laser to weld the plates 12 and 13 together.

In Figure 8, the glass plates 12 and 13 can be welded to one another by applying a laser beam B in direction D along the cut edge thereby melting the glass plates 12, 13 and forming a seal between the plates 12 and 13. To aid clarity of Figure 8, the light polarising substrates and the conductive layers are not shown and the card drivers and associated TAB's have also been omitted.

In a third embodiment of the process, not illustrated, the liquid crystal within the liquid crystal display or a part thereof can be frozen or have its viscosity reduced using liquid nitrogen and both plates can then be machined through in one action using, for example, a diamond wheel cutter. In this manner the risk of contamination of the liquid crystal is mitigated and the number of voids introduced into the liquid crystal is reduced.

Should a liquid crystal display be required with a larger operative region then, as shown in Figure 9, four liquid crystal displays 10 can be prepared as described with reference to Figure 5 and can have their respective operative regions 24 combined by aligning and

abutting their respective cut edges 27 and 28, the four liquid crystal displays 10 then being laminated to form a single display with increased operative area. Such lamination is preferably achieved by adhering transparent plates to the entire front and back surfaces of the four operative regions 24 using an optically clear ultra-violet cured adhesive.

The processes described above allow rectangular or square format liquid crystal displays, with reduced or increased operative areas, to be produced quickly and cheaply by reshaping standard commercial rectangular shaped displays which are currently produced in vast quantity at low unit cost and with high quality. Furthermore, since the shaping process is only limited by the positioning of the cards drivers 19, 20 and the excess regions 23, 26 to be deactivated, the process could also be used to produce liquid crystal displays of other shapes, including chamfered corners as taught by Figure 4, curved shapes taught by Figures 6 and 7 and also L-shaped and triangular-shaped formats.

The above process is effective for removing an excess region of a pre-manufactured liquid crystal display in which the cards drivers are relatively simple in format with only a few passive devices associated with each TAB. Where more complex circuitry exists and the card drivers cannot simply be cut, the process described above can be limited to the technique for cutting the transparent plates, the driver cards then being re-engineered or re-positioned using flexible circuit extensions.

The groove or final cut edge of each plate in a liquid crystal display may be arranged such that it forms an oblique angle. In this manner a greater surface area is presented for sealing or bonding to a second liquid crystal display arranged to abut the first liquid crystal display

when forming a display having a greater operative area.

Figure 10 illustrates apparatus 31 to aid removal of an excess area 23 from a pre-manufactured liquid crystal display 10. As described above, the liquid crystal display 10 comprises liquid crystal 11 sealed between first and second parallely spaced glass plates 12, 13 which also define an operative region 24 that is to be retained. To aid clarity of Figure 10, the light polarising substrates and the conductive layers are not shown, and the card drivers are also omitted. However, these would typically be arranged as described above with reference to Figure 1.

A groove 32 has been formed part-way through the glass plate 12 as described above. The apparatus 31 comprises a fracturing platform 33 having a light polarising layer 34 located between transparent first and second supporting surfaces 35, 36. A radiation source 37, for instance a light source, is arranged to emit radiation through the fracturing platform 33. A raised region, in the form of a ridge 38, is carried by the first supporting surface 25 and is arranged to contact the lower glass plate 13 of the liquid crystal display 10 along a line coinciding with the groove 32 formed in the transparent plate 12.

The apparatus also comprises a light polarising layer 39 disposed between an operator's eye position 40 and the liquid crystal display 10 which is positively located on the fracturing platform 33.

In operation, the operator observes the liquid crystal display 10 as a dark area since radiation from source 37 is polarised by the layer 34, polarised by the liquid crystal 11 and further

polarised by the layer 39. As the operator applies pressure to the excess region 23, the glass plate 12 will start to fracture along groove 32. As the fracture spreads along the groove 32, it will appear as a light area against the dark area background of the liquid crystal display 10 since the thickness of the liquid crystal 11 is different in the regions where fracture has occurred than in those where it has not, varying the degrees of lighting. Radiation will therefore not be polarised by the liquid crystal 11 along the fracture.

Once a fracture in the glass plate 12 has been achieved, a groove corresponding to groove 32 is formed in the glass plate 13 as has been described above. The liquid crystal display 10 is then turned over and repositioned on the fracturing platform 33 with the glass plate 12 contacting the raised edge 38 along either the line of the groove 32 or the line of the corresponding groove in glass plate 13. Again pressure is applied by the operator to the excess region 23 so as to fracture the glass plate 13 along its corresponding groove. When both glass plates 12 and 13 have been fractured along their respective grooves 32, the excess region 23 is removed and the gap between the fractures sealed as described above.

Alternatively, the liquid crystal display 10 can have grooves 32 on both plates 12, 13 prior to fracturing as described above. As a further alternative, once a plate 12 or plates 12, 13 have had grooves 32 applied, the liquid crystal display is placed on the raised edge 38 such that the excess region 23 contacts the raised edge 38 and a downward pressure is applied to groove or grooves 32 to fracture the plate 12 or plates 12, 13.

CLAIMS

1. A method of manufacturing a liquid crystal display having a liquid crystal sealed between first and second substantially parallely spaced transparent plates which form an operative area of the display, comprising removing an excess region of a pre-manufactured liquid crystal display by cutting the first and second plates to isolate the excess region of the first and second plates and to expose cut edges along the operative areas of the first and second plates.

2. A method, as in Claim 1, including cutting the first and second plates at an oblique angle.

3. A method, as in Claims 1 or 2, including removing the excess region of the pre-manufactured liquid crystal display by forming a first groove in the first plate of sufficient depth to isolate the excess region of the first plate, forming a second groove in the second plate of sufficient depth to isolate the excess region of the second plate, the second groove being substantially aligned with the first groove, and fracturing the first plate and second plate along their respective grooves.

4. A method, as in Claim 3, including forming the first and second grooves simultaneously.

5. A method, as in Claim 3 or 4, including fracturing the first and second plates simultaneously along the first and second grooves.

6. A method, as in Claim 3, including fracturing the first plate along the first groove prior to forming the second groove in the second plate and fracturing the second plate along the second groove.

7. A method, as in Claims 3 to 6, including fracturing each grooved plate by placing the other plate on a ridge substantially corresponding with the groove and applying pressure to the excess region.

8. A method, as in Claim 7 and wherein the liquid crystal display is placed on an apparatus comprising a fracturing platform having a first light polarising layer to polarise radiation emitted from a radiation source and a second light polarising layer located between a viewer's eye position and the liquid crystal display, including viewing the propagation of each fracture along its groove as an area against a contrasting background through the second light polarising layer.

9. A method, as in Claims 1 or 2, including removing the excess region of the pre-manufactured liquid crystal display by cutting the first and second plates using a laser beam thereby isolating the excess region of the first and second plates and exposing the cut edges along the operative areas of the first and second plates.

10. A method, as in any preceding claim, including freezing the liquid crystal between the first and second plates prior to cutting the first and second plates.

11. A method, as in Claim 1 or 2, including removing the excess region of the pre-manufactured liquid crystal display by freezing the liquid crystal between the first and second plates and machining through the first and second plates thereby isolating the excess region of the first and second plates and exposing the cut edges along the operative areas of the first and second plates.

12. A method, as in any preceding claim and wherein conductive layers are adhered to the first and second plates and are electrically connected to driver connections, including cutting and removing any driver connection associated with the excess region prior to cutting the first and second plates.

13. A method, as in any preceding claim and wherein a light polariser is adhered to at least one of the plates, including cutting and removing a narrow strip of each light polariser in a region either side of where the cut edges associated with each plate is to be formed.

14. A method, as in any preceding claim, including removing air voids within the liquid crystal display by applying pressure to at least one of the plates.

15. A method, as in any preceding claim, including sealing the exposed cut edges to retain the liquid crystal between the first and second plates.

16. A method, as in Claim 15, including sealing the exposed cut edges using a laser beam arranged to melt the first and second plates together along the exposed cut edges.

17. A method, as in Claims 1 to 14, including removing an excess region from at least two pre-manufactured liquid crystal displays to leave exposed cut edges, aligning and positioning the exposed cut edges of one of the liquid crystal displays with the corresponding exposed cut edges of an adjacent liquid crystal display, and laminating the liquid crystal displays to form a single display with increased operative area.

18. A method substantially as illustrated in and/or described with reference to any of the accompanying drawings.

19. A liquid crystal display manufactured by the method of any preceding claim.

20. A liquid crystal display comprising a pre-manufactured liquid crystal display having a liquid crystal sealed between first and second parallely spaced transparent plates and in which an excess region of the pre-manufactured liquid crystal display has been removed by cutting both of its transparent plates along a common line.

21. A liquid crystal display, as in Claim 20, wherein the first and second plates are cut at an oblique angle.

22. A liquid crystal display, as in Claims 20 or 21, wherein the cut edges of the transparent plates have been resealed to retain the liquid crystal.

23. A liquid crystal display, as in Claim 22, wherein a laser beam has been used to melt

the first and second plates together.

24. A composite liquid crystal display comprising at least two liquid crystal displays in accordance with Claims 20 or 21 supported with their respective cut edges aligned and abutting.

25. A composite liquid crystal display, as in Claim 24, in which the cut edges are supported in alignment by a transparent lamina adhered over their first transparent plates.

26. A composite liquid crystal display, as in Claim 25, in which the cut edges are additionally supported in alignment by a second lamina adhered over their second transparent plates.

27. A liquid crystal display substantially as illustrated in and/or described with reference to any of Figures 2 to 8 of the accompanying drawings.

28. A composite liquid crystal display substantially as illustrated in and/or described with reference to Figure 9 of the accompanying drawings

29. Apparatus, to aid removal of an excess region of a pre-manufactured liquid crystal display having liquid crystal sealed between first and second parallel spaced transparent plates which form an operative area of the display and in which a groove has been formed in one of the plates between the excess region and an operative

region of the liquid crystal display, comprising

a fracturing platform having a light polarising layer located between transparent first and second supporting surfaces,

a radiation source located to emit radiation through the fracturing platform,

a raised region arranged on an opposite surface of the fracturing platform to which the light source is located, the raised region being arranged to contact a plate of the liquid crystal display in a region substantially corresponding to the groove in the other plate, and

a light polarising layer disposed between a viewer's eye position and a liquid crystal display located on the fracturing platform.

30. Apparatus, as in Claim 29, wherein the operative area of the liquid crystal display is clamped to the fracturing platform whilst leaving the excess region freedom to move.

31. Apparatus, as in Claims 29 or 30, wherein the raised region is a ridge.

32. Apparatus, substantially as illustrated in and/or described with reference to Figure 10 of the accompanying drawings.